RESEARCH/INVESTIGACIÓN

ASSESSMENT OF SELECTED PECAN AND PEACH ROOTSTOCKS FOR RESISTANCE TO *MELOIDOGYNE PARTITYLA*

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ABSTRACT

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Open pollinated pecan seedling rootstocks were evaluated for resistance to *Meloidogyne partityla*, *M. arenaria*, and *M. incognita* in the greenhouse. Rootstocks tested included seedlings derived from open pollinated seed of 'Apache', 'Caddo', 'Curtis', 'Moneymaker', 'Pawnee', 'Schley', 'Stuart', and 'Wichita' parent trees. 'Elliott', a susceptible pecan rootstock for *M. partityla*, was included as the control. All open pollinated pecan rootstocks supported nematode reproduction as indicated by number of egg masses per plant, number of eggs per plant, and number of eggs per gram dry root, regardless of nematode species. Reproduction by *M. partityla* was greater ($P < 0.05$) on all pecan rootstocks than *M. incognita* and *M. arenaria*, indicating that pecan is a better host for *M. partityla*. All pecan seed sources were rated as good hosts (susceptible) to *M. partityla* infection and as poor hosts (resistant) to *M. incognita* and *M. arenaria*. In another greenhouse study, open pollinated 'Elliott' seedlings supported greater ($P < 0.01$) reproduction of M. partityla than seedlings from Guardian®, 'Lovell', 'Halford', 'Flordaguard' and 'Nemaguard' peach. All peach rootstocks were rated as non-hosts (highly resistant) to *M. partityla* infection. Interplanting pecan and peach trees in a commercial orchard environment does not appear to exacerbate the *M. partityla* population density between the two perennial crops in the southeastern United States.

Key words: Carya illinoinensis, host parasitic relationship, management, *Meloidogyne arenaria, Meloidogyne incognita, Meloidogyne partityla*, peach, pecan, *Prunus persica*, resistance, root knot nematode, susceptible.

RESUMEN

Nyczepir, A. P. and B. W. Wood. 2012. Evaluación de la Resistencia a *Meloidogyne partityla* de Portainjertos Selectos de Pacano y Duraznero. Nematropica 42:281-286.

En un estudio de invernadero, se evaluó la resistencia a *Meloidogyne partityla*, *M. arenaria*, y *M. incognita* de plántulas de portainjertos de pacano. Los portainjertos evaluados se derivaron de semilla de polinización abierta provenientes de padres de las variedades 'Apache', 'Caddo', 'Curtis', 'Moneymaker', 'Pawnee', 'Schley', 'Stuart', y 'Wichita'. Se incluyó 'Elliott', un portainjerto susceptible a *M. partityla*, como control. Todos los portainjertos de polinización abierta fueron susceptibles a las tres especies y permitieron la reproducción del nematodo, medida en términos de cantidad de masas de huevos por planta y cantidad de huevos por gramo de raíz seca. La reproducción de *M. partityla* fue mayor ($P < 0.05$) en todos los portainjertos de pacano que la de *M. incognita* y *M. arenaria*, lo cual indica que el pacano es un mejor hospedante para *M. partityla*. Todas las fuentes de semilla de pacano resultaron ser buenos hospedantes (susceptibles) para *M. partityla* y malos hospedantes (resistantes) para *M. incognita* y *M. arenaria*. En otro estudio de invernadero, las plántulas de polinización abierta de 'Elliott' mostraron reproducción más alta ($P < 0.01$) de *M. partityla* que las plántulas de duraznero de Guardian®, 'Lovell', 'Halford', 'Flordaguard' y 'Nemaguard'. Todos los portainjertos de duraznero mostraron ser no hospedantes (altamente resistentes) para *M. partityla*. La siembra intercalada de árboles de pacano y duraznero en plantaciones comerciales no parece aumentar la densidad de población de *M. partityla* entre los dos cultivos perennes en el sureste de Estados Unidos.

Palabras clave: Carya illinoinensis, duaznero, manejo, *Meloidogyne arenaria*, *Meloidogyne incognita*, *Meloidogyne partityla*, nematodo agallador, pacano, *Prunus persica*, relación hospedante-parásito, resistencia, susceptible.

INTRODUCTION

Pecan (*Carya illinoinensis*) is increasingly cultivated worldwide and is North America's most valuable native tree-nut crop, with world production concentrated in the United States and Mexico (Wood, 1994; Wood *et al.*, 1990). United States kernel production alone was approximately 136,000 MT in 2011 (Anonymous, 2012). Pecan trees are attacked by a wide variety of disease, insect pests, and nematodes that potentially reduce tree productivity if not properly managed.

Root-knot nematodes are considered the most damaging plant-parasitic nematodes in the world and can be found in temperate, tropical and equatorial agricultural producing areas (Sasser, 1979; Sasser and Freckman, 1987; Nyczepir and Thomas, 2009). Reports of *Meloidogyne* spp. parasitizing pecan throughout the world are limited. Prior to 1996, three species of *Meloidogyne* reported parasitizing pecan roots include *M. incognita* (Kofoid and White) and *M. arenaria* (Neal) Chitwood from the United States (Hendrix & Powell, 1968; Carithers, 1978; Johnson, 1986) and *M. partityla* from South Africa (Kleynhans, 1986). In 2002, the pecan root-knot nematode, *M. partityla*, was found on pecan in the southeastern United States and was associated with stressed trees exhibiting dead branches in the upper canopy and/or typical mouse-ear (ME) associated foliar symptoms (Nyczepir *et al*., 2002). This was the first report of *M. partityla* on pecan in Georgia and the third report of this nematode outside South Africa. The first report of *M. partityla* on pecan within the United States was by Starr *et al.* (1996). In 2006, it was reported in controlled field microplot studies that severity of ME symptoms, and thus Nickel (Ni) deficiency, in pecan trees was enhanced by the presence of *M. partityla* (Nyczepir *et al*., 2006). The first experimental proof of pathogenicity between *M. partityla* and pecan was reported by Nyczepir and Wood (2008), which explained the above-ground stunting of trees observed in the presence of *M. partityla* in commercial pecan orchards in the southeastern United States.

In Georgia, peach growers sometime interplant with pecan, so that when peach orchard productivity declines the peach trees are removed to yield a young pecan orchard (J. Cook, University of Georgia Coop. Ext. Serv, pers. com). This practice raises questions regarding the host susceptibility of peach to *M. partityla.*

There are presently no recommended nematode resistant rootstocks, effective chemical nematicides, or biological agent control strategies available for managing *M. partityla* on pecan. Finding a nonchemical control strategy for *M. partityla* is therefore warranted. Resistance to *M. partityla* in pecan and peach rootstocks is unknown. This research evaluates the host susceptibility of certain common pecan and peach rootstocks for resistance or tolerance to *M. partityla, M. incognita*, and/or *M. arenaria*.

MATERIALS AND METHODS

Nematode source and inocula

Eggs of *M. partityla*, originating from a commercial pecan orchard with ME symptoms and stunted growth in Cobb, Georgia, were extracted directly from the roots of a single tree. Identification of the root-knot nematode as *M. partityla* was confirmed using the esterase phenotype technique (Esbenshade and Triantaphyllou, 1985). Populations of *M. incognita* isolated from peach in Georgia and *M. arenaria* from soybean in South Carolina were both maintained on tomato (*Solanum esculentum* Mill. cv. 'Rutgers') in the greenhouse. Root-knot nematode egg inoculum was extracted from tomato roots using NaOCl solution (Hussey and Barker, 1973).

Pecan rootstock experiment

Eight pecan rootstocks were evaluated for host susceptibility to *M. partityla*, *M. incognita*, and *M. arenaria* in an air-conditioned greenhouse. Stocks included seedlings of 'Apache', 'Caddo', 'Curtis', 'Moneymaker', 'Pawnee', 'Schley', 'Stuart', and 'Wichita' cultivars produced from open pollinated seed. The susceptible pecan 'Elliott' rootstock was included as the control for *M. partityla*. Individual pecan seedlings (33-d-old) were planted in separate 15 cm dia plastic pots containing 1,500 cm^3 steam pasteurized loamy sand (86% sand, 10% silt, 4% clay; pH 6.1; 0.54% organic matter). Nine days later, pots were inoculated with either 1,400 *M. partityla, M. incognita* or *M. arenaria* eggs/1,500 cm^3 soil; which is equivalent to 93 *Meloidogyne* sp. eggs/100 cm^3 soil. Approximately 700 eggs were pipetted directly into each of two holes (2.5 cm-deep), one on either side of the plant stem. The holes were covered and additional water applied to settle the potting medium around the eggs. Treatments were replicated 10 times in a randomized complete block with a split plot design on benches in a greenhouse. The whole plot factor was nematode treatment, with rootstock as the sub plot factor. Two replications each of 'Rutgers' tomato was inoculated with either *M. incognita* or *M. arenaria* eggs to determine inoculum viability. Pecan and tomato seedlings were watered daily as needed and tomato seedlings fertilized as needed with Osmocote (14-14-14). The greenhouse temperatures ranged from 21 to 35°C. The study was terminated 160 days after inoculation and the following data were collected: number of egg masses per root system, number of eggs per root system, number of root galls per root system, and dry root weight (dried at 70°C in aluminum foil until no more loss in weight occurred). Root systems were also rated for number of egg masses produced (Taylor and Sasser, 1978). The egg mass index consisted of a 0 to 5 scale, with 0 = no egg masses, 1 = 1 to 2 egg masses, 2 = 3 to 10 egg masses, 3 = 11 to 30 egg masses, 4 = 31 to 100 egg masses, and 5 = > 100 egg masses. Host susceptibility was determined according to the egg mass index rating scale as follows: 0 = nonhost (highly resistant), 1-2 = a poor host (resistant), and > 3 = a good host (susceptible). The test was repeated one time. Modifications were made in the second test that included inoculation of 11-day-old pecan seedlings with 1,400 *Meloidogyne* spp. eggs/1,500 cm^3 of medium, evaluation of only Elliott and Curtis seedlings (the only two pecan rootstocks currently used in the Southeast), and the study was terminated after 164 days following inoculation.

Peach rootstock experiment

'Nemaguard', 'Lovell', and Guardian® (i.e., advanced line SC 3-17-7) peach rootstocks were evaluated for host susceptibility to *M. partityla* in an air-conditioned greenhouse. Pecan (open pollinated seed from susceptible Curtis rootstock) was included as the control. Individual peach (123-d-old) or pecan (56-d-old) seedlings were planted in separate 15 cm dia plastic pots containing 1,500 cm^3 steam pasteurized loamy sand (86% sand, 10% silt, 4% clay; pH 6.1; 0.54% organic matter). Four days later, pots were inoculated with 1,500 *M. partityla* eggs/1,500 cm^3 medium; which is equivalent to 100 *M. partityla* eggs/100 cm^3 soil. Approximately 750 eggs were pipetted directly into each of two holes (2.5 cm-deep), one on either side of the plant stem. The holes were covered and additional water applied as previously described. Treatments were replicated eight times in a randomized complete block design on benches in a greenhouse (temperature range of 21 to 35°C). Peach and pecan seedlings were watered daily and fertilized as needed with Osmocote (14-14-14). The study was terminated 127 days after inoculation and similar data were collected as described in the pecan greenhouse study. Root systems were also rated for number of egg masses produced as described above (Taylor and Sasser, 1978). The test was repeated one time. Modifications were made in the second test that included the transplanting of 55-day-old peach and 25 day-old pecan seedlings into pots and inoculated three days later, the addition of 'Halford' and 'Flordaguard' peach rootstocks, the substitution of Elliott for Curtis seedling pecan stock as the susceptible control, and the study was terminated after 129 days following inoculation.

Statistical analysis

Nematode data were subjected to analysis of variance with the general linear models (GLM) procedure of SAS (SAS Institute, Cary, NC). For the pecan rootstock test, means were compared according to Fisher Protected least significant difference (LSD) test following a significant F test. For the peach rootstock test, appropriate preplanned single-degree-of-freedom comparisons were used to detect differences between treatment means for pecan vs. individual peach rootstocks according to Dunnett's test following a significant F test. Only significant differences ($P < 0.05$) will be discussed unless stated otherwise.

RESULTS

Pecan rootstock experiment

The interaction between rootstock and nematode was nonsignificant for all parameters; therefore, only 'main-effect' values are reported. All pecan rootstocks in both tests supported nematode reproduction as indicated by number of egg masses per plant, number of eggs per plant, and number of eggs per gram dry root, regardless of nematode species (Table 1). Even though statistical differences occurred among rootstocks within a given nematode reproduction parameter in test 1, no one rootstock consistently suppressed nematode reproduction more than another. In tests 1 and 2, no differences in number of egg masses per plant, number of eggs per plant, and number of eggs per gram dry root were detected between Curtis and Elliott rootstocks (the two current commercial rootstocks), except for number of eggs per plant in test 1. Furthermore, root galling also occurred on all pecan rootstocks evaluated in both tests, regardless of nematode species.

Our results also indicate that differences in nematode reproduction were detected among *M. partityla, M. incognita*, and *M. arenaria*, regardless of rootstock. Reproduction by *M. partityla*, as indicated by number of egg masses per plant, number of eggs per plant, and number of eggs per gram dry root was greater ($P < 0.05$) on all pecan rootstocks than *M. incognita* and *M. arenaria* in both tests, indicating that pecan is a better host for *M. partityla* (Table 1). There were no differences in any of the reproduction parameters on pecan between *M. incognita* and *M. arenaria* in both tests. It is also important to note that gall formation in pecan roots parasitized by *M. partityla* was more ($P < 0.05$) abundant than those produced by either *M. incognita* or *M. arenaria*, regardless of rootstock. No differences in number of galls produced in pecan were detected between *M. incognita* and *M. arenaria*. Reproduction on tomato by *M. incognita* and *M. arenaria*, as measured by eggs per plant, was 33,100 and 182,000 (Test 1), and 22,500 and 32,000 (Test 2), respectively, indicating that the nematode inoculum was viable. In both greenhouse tests, pecan would be rated a good host (susceptible) to *M. partityla* infection based on the number of egg masses recovered (> 95) and poor hosts (resistant) to *M. incognita* (< 4) and *M. arenaria* (< 4).

Peach rootstock experiment

Curtis and Elliott pecan (both known susceptible) supported greater ($P < 0.01$) reproduction of *M. partityla* than Guardian®, Lovell, and

Table 1. Reproduction of *Meloidogyne arenaria, M. incognita* and *M. partityla* on nine pecan rootstocks in the greenhouse 160 (test 1) and 164 (test 2) days after soil infestation.

	Egg masses/plant[v]		Eggs/plant		Eggs/g of dry root		Galls/plant[v]	
Treatment	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2	Test 1	Test 2
Rootstock[w]								
Curtis	38 ab	32 a	29,677 a	50,051 a	2,666 ab	4,118 a	40 ab	33 a
Elliott	33 bc	35 a	10,357 cd	73,419 a	1,535 b	7,207 a	34 bc	38 a
Caddo	34 bc	---[x]	23,726 abc	---	2,321 ab	---	34 bc	---
Pawnee	42 a	---	7,712 d	---	1,689 b	---	44 a	---
Apache	34 bc	---	25,197 ab	---	2,293 ab	---	34 bc	---
Wichita	31 c	---	10,074 cd	---	1,132 b	---	31 c	---
Moneymaker	34 bc	---	14,730 bcd	---	4,482 a	---	34 bc	---
Schley	38 ab	---	29,463 a	---	4,625 a	---	39 ab	---
Stuart	36 bc	---	13,779 bcd	---	1,827 b	---	37 bc	---
Nematode[w]								
M. partityla[y]	100 a	95 a	57,803 a	184,525 a	7,489 a	16,931 a	101 a	95 a
M. arenaria[yz]	4 b	2 b	397 b	163 b	58 b	14 b	5 b	3 b
M. incognita[yz]	2 b	4 b	219 b	518 b	25 b	43 b	4 b	7 b

Data are means of 10 replications. The interaction between rootstock and nematode was nonsignificant for number of egg masses per plant and number of galls per plant in Test 1 and Test 2.
[v]A maximum of 101 egg masses and galls were counted per plant.
[w]Means within a main effect and column followed by the same letter are not different ($P < 0.05$) according to the Fisher Protected LSD test.
[x] --- = not included.
[y]Initial population density of *Meloidogyne partityla, M. arenaria*, and *M. incognita* = 93 eggs/100 cm^3 soil.
[z]Number of eggs per plant by *M. incognita* and *M. arenaria* on tomato was 33,100 and 182,000 (Test 1), and 22,500 and 32,000 (Test 2), respectively.

Table 2. Reproduction of *Meloidogyne partityla* on selected peach and pecan rootstocks grown in the greenhouse 127 (test 1) and 129 (test 2) days after soil infestation.[w]

Plant species	Cultivar	Egg masses/plant[x] Test 1	Egg masses/plant[x] Test 2	Eggs/plant Test 1	Eggs/plant Test 2	Galls/plant[x] Test 1	Galls/plant[x] Test 2
Pecan	Curtis	101 ay	---z	50,375 ay	---	101 ay	---
	Elliott	---	101 ay	---	17,685 ay	---	101 ay
Peach	Guardian®	0 b	0 b	0 b	0 b	0 b	0 b
	Lovell	0 b	0 b	0 b	0 b	0 b	0 b
	Nemaguard	0 b	0 b	0 b	0 b	0 b	0 b
	Halford	---	0 b	---	0 b	---	0 b
	Flordaguard	---	0 b	---	0 b	---	0 b

Data are means of eight replications for Test 1 and 10 replications for Test 2.
[w]Initial population density of *Meloidogyne partityla* = 100 eggs/100 cm^3 soil.
[x]A maximum of 101 egg masses and galls were counted per plant.
[y]The single-degree-of-freedom comparison between the means for pecan vs. an individual peach cultivar was highly significant
($P < 0.01$) according to Dunnett's test.
[z] --- = not included.

Nemaguard peach rootstocks as indicated by number of egg masses per plant and number of eggs per plant in tests 1 and 2, respectively (Table 2). In test 2, Elliott pecan also supported greater *M. partityla* reproduction than Halford and Flordaguard. All individual peach rootstocks would be rated as nonhosts (highly resistant) to *M. partityla* infection based on the number of egg masses recovered (0 egg masses). Gall formation in pecan roots was also more ($P < 0.01$) abundant than those produced in the peach rootstocks in both tests. No differences in number of galls produced among the peach rootstocks were detected.

DISCUSSION

In the past, commercial peach growers have interplanted pecan trees within peach orchards, so that when the productivity of the peach orchard sufficiently declined, the peach trees were removed and the site transitioned to a pecan orchard. This practice still occurs among some of the larger peach growers in Georgia, but is now more limited in acreage. A common question asked by growers pertains to the host susceptibility of pecan and peach to *M. partityla*. In the pecan study, all pecan rootstocks including the two commercial pecan rootstocks (Curtis and Elliott) were ineffective in suppressing the reproduction of *M. partityla*, but were effective against *M. incognita* and *M. arenaria*. In a survey of South Carolina peach orchards, *M. incognita* was the predominant *Meloidogyne* spp. detected; occurring in 95% of the orchards sampled (Nyczepir *et al*., 1997). Based on our results, it appears that the presence of *M. incognita* or *M. arenaria* will not cause potential pathogenic problems for interplanted pecan trees. However, long-term field evaluation (1-2 years) of commercial Elliott and Curtis rootstocks infected with *M. partityla* needs further examination to determine i) if tree growth is reduced and ii) whether it will be necessary to utilize preplant management for this nematode parasite in pecan.

In the peach study, it is apparent that all five commercial peach rootstocks currently grown in the southeastern United States are nonhosts to *M. partityla*. Furthermore, the presence of *M. partityla* in a peach orchard interplanted with pecan trees will not be a potential pathogenic problem to the peach trees, because this root-knot nematode species preferentially parasitizes pecan and not peach. These data also substantiate the research reported by Marais and Heyns (1990) who demonstrated that peach (cv. 'Albatros') is a nonhost (0 egg masses detected) to *M. partityla* under greenhouse conditions in South Africa. While the mode of action of nematode suppression in these peach (vs. *M. partityla*) and pecan (vs. *M. incognita* & *M. arenaria*) rootstocks was not addressed in the present study, two possible mechanisms of nematode suppression might be i) the inability of the respective *Meloidogyne* sp to complete its life cycle and/or ii) the occurrence of natural plant metabolites in pecan or peach roots that deter reproduction. For example, *M. incognita* J2 penetrated Guardian® roots and formed galls, but the majority of the nematodes failed to mature and reproduce (Nyczepir *et al*., 1999).

In summary, we found that five commercial peach rootstocks evaluated are nonhosts (highly resistant) for *M. partityla*, but that all pecan rootstock (including two commercial pecan rootstocks; Curtis and Elliott) are good hosts (susceptible). Our findings also indicate that a need for further study pertaining to the development of IPM management strategies (i.e., biological control) for control of *M. partityla* on pecan and their affects on orchard profitability is warranted.

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NOTE: Mention of trade names or commercial products in this publication is solely for the purpose of providing specific information and does not imply recommendation or endorsement by the U.S. Department of Agriculture.

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